Volume 44 DECEMBER, 1958 *Number 12*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

This Issue

DEVELOPMENT OF A NEW MOTOR OIL

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

Radioactive Cobalt-60 provides a gamma-ray "hot cell" at Beacon Research Laboratory, Beacon, N. Y. In addition to this unit, the new lab has a 6-to-10-million volt linear electronic accelerator and a 3-million volt Van de Graaf positive ion accelerator.

RADIATION PROBING
at Texaco's new nuclear lab
to crack secret of better lubricants

Lubricants finer than the ones available from even the most advanced standard refining techniques may soon be produced by Texaco—with the help of nuclear radiation. Completely new lubricants are a real possibility, too—lubricants with an atomic structure stronger and more cohesive than anything now available.

To open up this new frontier in lubrication, Texaco has assembled the most fully equipped nuclear laboratory in American industry. Texaco scientists are studying the effects of all four basic irradiation forces—electrons, positive ions, gamma rays and neutrons—and are now probing the activity of hydrocarbon molecules during refining.

The Texas Company, 135 East 42nd Street, New York 17, N. Y.

TEXACO

IN ALL 48 STATES

LUBRICATION IS A MAJOR FACTOR IN COST CONTROL

(PARTS, INVENTORY, PRODUCTION, DOWNTIME, MAINTENANCE)

LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

Published by

The Texas Company, 135 East 42nd Street, New York 17, N. Y.

Vol. XLIV December, 1958 No. 12

Change of Address: In reporting change of address kindly give both old and new addresses.

Development of a New Motor Oil

SINCE the term "motor oil" means many things to many people, it is desirable to begin by defining it more precisely for the purpose of this discussion as a *crankcase* oil intended primarily for use in passenger automobiles.

Motor oil represents an extremely important portion of the petroleum industry's business. For example, it has been estimated that by 1960 the annual production of lubricating oil for passenger cars will reach 600 million gallons.[1] The retail value of this product would be in the vicinity of $1 billion.

Viscosity Grades

As most consumers are aware, motor oils are manufactured in a number of viscosity grades, which are defined by SAE numbers. (The letters SAE stand for "Society of Automotive Engineers"). These numbers range from SAE 5W for the lowest viscosity to SAE 50 for the highest. The SAE Crankcase-Oil Viscosity classification system was devised to get away from such meaningless terms as "light", "medium" and "heavy".

Table I shows the viscosity requirements for each of the SAE grades. It will be noted that an oil will qualify as SAE 10W if it meets either of a pair of viscosity specifications, and the same is true of the SAE 20W grade. The first specification for each of these two grades is based solely on a range of viscosity at 0°F., and the other on a maximum viscosity at 0°F. in combination with a minimum viscosity at 210°F. In both cases the limits are designed to insure satisfactory winter starting (hence the "W") in addition to adequate lubrication at normal engine operating temperatures. However, since the SAE grades are based solely on viscosity and have no relation to "detergency", "pour point" or any other properties, they do not of themselves stamp an oil as suitable for operation under any given conditions.

[1]Petroleum Refiner—235 (May 1956)

Multi-Grading

Since the SAE Crankcase-Oil Viscosity Classification System is based on viscosities at the two different temperatures of 0°F. and 210°F., it becomes possible for a single oil, if properly formulated, to meet the viscosity requirements of more than one SAE grade. For example, an oil having a viscosity of 10,000 seconds at 0°F. and 59 seconds at 210°F. falls within the SAE 10W range of 6,000 to 12,000 seconds at 0°F., and also the SAE 30 range of 58 to 70 seconds at 210°F. It has become the practice to identify such an oil as SAE 10W-30. Similarly, it is possible to make such combinations as 5W-20, 20-20W and 20W-40, for example. The principal advantage of multi-graded oils is that, other factors being equal, they allow the engine to be operated safely over a wider range of atmospheric temperatures than do single-graded oils. At the present time SAE 20-20W, 20W-40 and 10W-30 oils are being widely marketed. These

TABLE I

SAE Crankcase-Oil Viscosity Classification System

SAE Viscosity Grade Number	Viscosity, Saybolt Universal Seconds At 0°F Minimum	At 0°F Maximum	At 210°F Minimum	At 210°F Maximum
5W	–	4,000	39	–
10W	6,000	12,000	–	–
10W	–	12,000	40	–
20W	12,000	48,000	–	–
20W	–	48,000	45	–
20	–	–	45	58
30	–	–	58	70
40	–	–	70	85
50	–	–	85	110

multi-graded products, together with the single graded SAE 10W and 30 oils account for almost all of the passenger car consumption of motor oil.

API Service Classification

Motor oils are also classified (by the American Petroleum Institute) according to the severity of service for which they are designed. Thus, products formulated for light, moderate and severe gasoline engine service are designated respectively ML, MM and MS. Since most high quality motor oils for service station distribution are now of the MS classification, attention will be focused on products of this type.

Additives

The use of chemical addition agents, or additives has become so widespread that all top-quality motor oils now contain one or more of these materials. The reason for their use is that they impart performance capabilities which even the finest non-additive oils do not have.

RESEARCH AND DEVELOPMENT

When a petroleum company commits itself to marketing a line of motor oils on a wide geographical basis, it should also commit itself to an expensive and continuing research and development program. This is necessary in order to be able always to provide the consumer with products of the highest quality consistent with prices. The trend in engine development toward higher output, resulting in higher loads and higher temperatures, has placed a heavier and heavier burden on the crankcase oil. It must be assumed that this will continue to be the case, hence the never-ending search for better and better products. Anticipating the needs of the engines of five and ten years from now thus becomes an important goal of a motor oil research and development program.

Supporting Activities

In addition to the men and facilities assigned to the actual formulation of new motor oils, a well-balanced program requires a number of supporting activities. Some of these are as follows:

1. Analytical laboratories
2. Bench and engine test facilities
3. New test development programs
4. Fundamental research on oil-additive chemistry
5. Research on new additives
6. Processing research on base oils
7. Effective liaison with car manufacturers
8. Extensive testing of new cars
9. Comprehensive road tests
10. Continuing evaluation of customer reaction and field experience

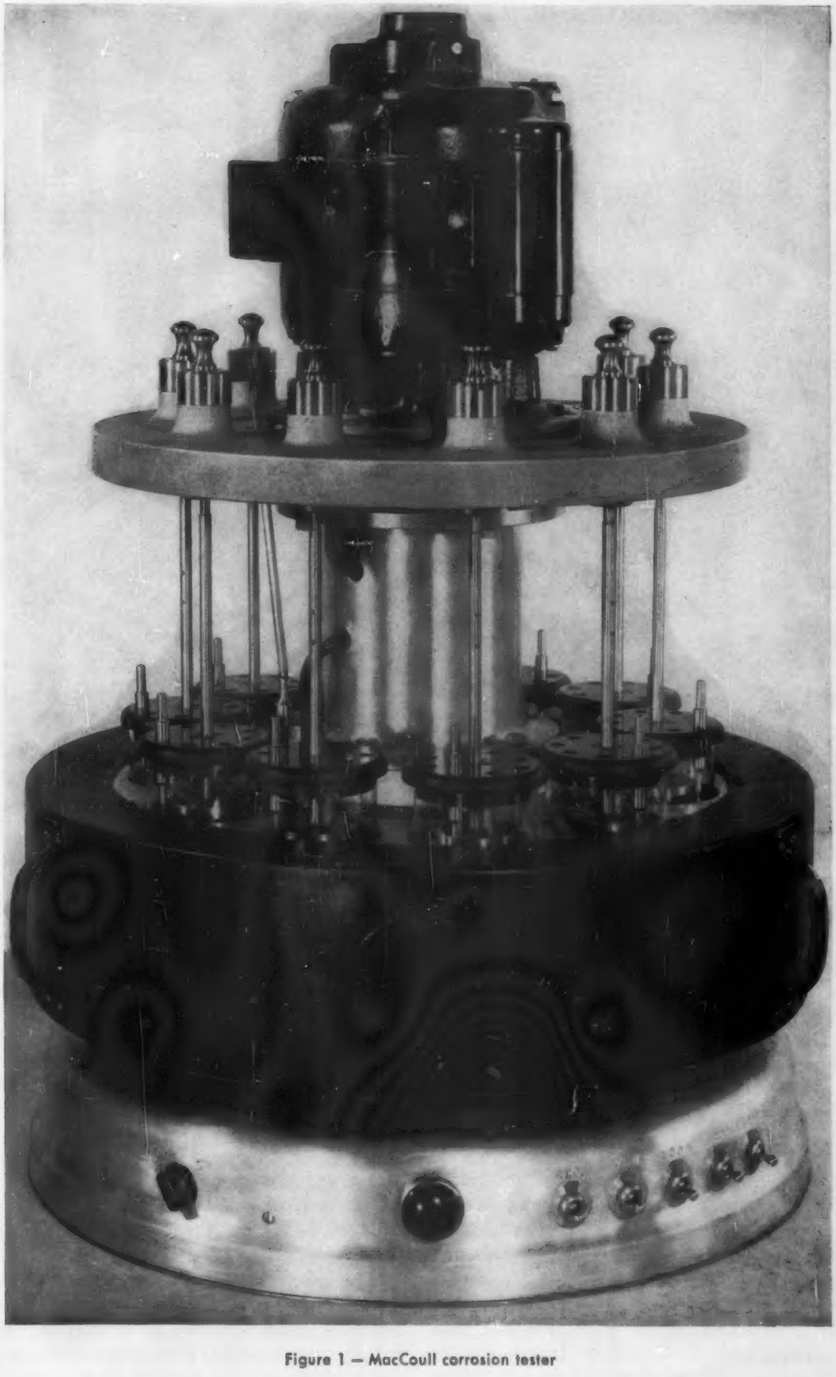


Figure 1 — MacCoull corrosion tester

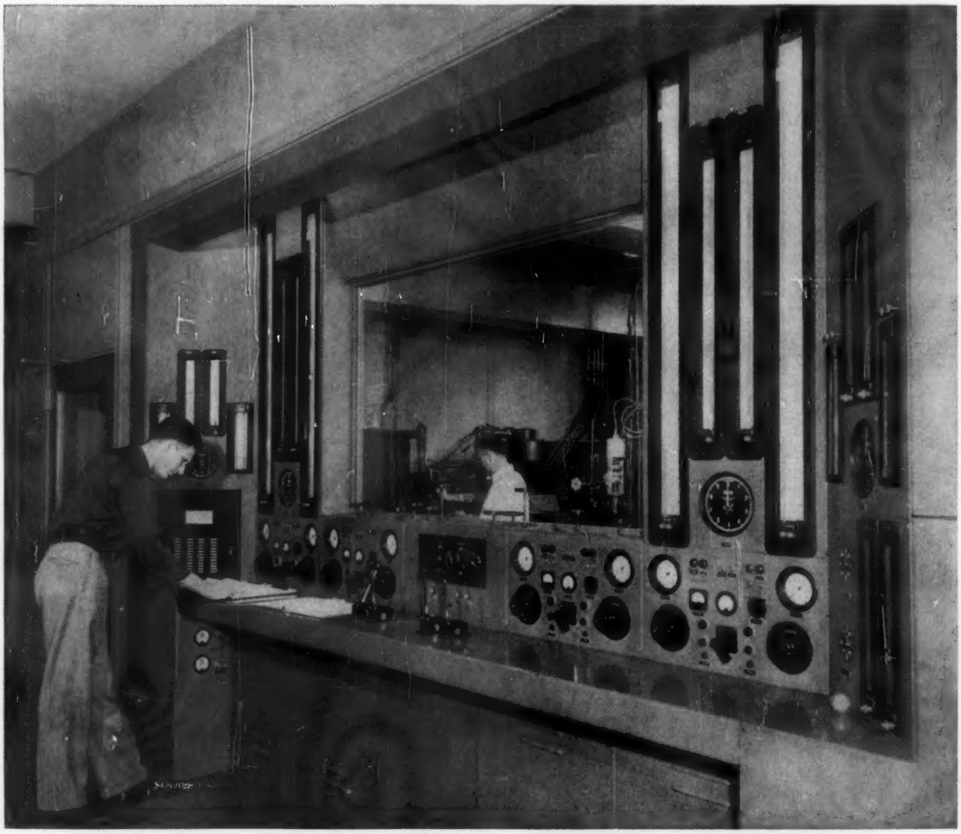


Figure 2 — Modern engine test cell with external instrumentation and controls

Analytical Facilities

Analytical facilities are needed in all stages of preparing and testing new motor oils. Unused products must be examined to be sure physical properties meet specifications, and that the proper amounts of additive are present. Later, the used oils must be analyzed at various stages of bench and engine testing. The latter data show the extent and nature of any deterioration and are essential in evaluating overall performance.

Bench and Engine Test Facilities

Bench tests, as the name implies, are small-scale tests which the motor oil researcher uses to "screen" numerous formulations, and thereby to predict which ones are likely to perform best in a full-scale engine. The MacCoull Corrosion Test shown in Figure 1 is typical of many used throughout the petroleum industry. Its particular function is to provide a preliminary evaluation of an oil's ability to protect alloy bearings against the corrosive effect of fuel and oil oxidation products.

Through the judicious use of bench tests, a motor oil research and development program can be expedited, and, at the same time a substantial amount of money can be saved. These savings result primarily from a reduction in the amount of expensive engine testing that would otherwise be required. Nevertheless, no matter how efficient their preliminary testing program may be, any group working on motor oil research must have an engine testing laboratory at its disposal. In addition to the well-known Chevrolet L-4 bearing corrosion and the Caterpillar L-1 Diesel cleanliness test engines, other single and multi-cylinder engines must be available. The latter will be required to insure that new and improved products will be able to deal effectively with such problems, to name a few, as valve train wear, low temperature deposits, low temperature ring wear and surface ignition. A view of one section of a

modern lubricating oil engine test laboratory is shown in Figure 2.

New Test Development

Hand-in-hand with the evaluation of experimental motor oil formulations must go a vigorous program of new test development. The purposes of this work are (a) to anticipate performance problems of future engines before they arise, if possible, and (b) to devise bench and engine tests which simulate the expected difficulty. These new tests, which are invariably more critical and severe than their predecessors, can then be used to develop improved products.

Fundamental Research

The discussion thus far has been concerned with applied motor oil research — that is, the development of new information related directly to the development of improved motor oils. *Fundamental* research may be defined as a program of investigation whose purpose is to extend the fund of basic knowledge in a given field without relation to any particular product or process. Experience has shown that, over a period of time, a program of fundamental research in the general field of lubrication pays real dividends in the development of improved motor oils. For example, a better knowledge of the mechanism of the wear process may aid in the discovery or selection of a better anti-wear additive for a new product. Similarly, an understanding of the mechanism by which pure hydrocarbons are degraded under oxidizing conditions may help subsequently in the selection of a suitable base oil for use either with a new additive, or under more severe service conditions.

Additive Synthesis and Evaluation

It is not an exaggeration to say that without a continual flow of new additives, any well-integrated motor oil research program must eventually stagnate. The reason for this is that a new lubrication problem frequently requires a new approach from the additive standpoint. It is, therefore, highly desirable to have an organic synthesis group working in cooperation with a motor oil development project. The functions of such a group are to supply additives designed to meet specific performance problems, to assist in the conversion from laboratory to plant scale manufacture of additives and to plan new and novel additives and ways to make them.

The "Additive Tree" shown in Figure 3 illustrates some of the functions which lubricating oil additives perform. It serves to underline the need for an active program of additive synthesis as an integral part of the overall effort on motor oil development. Those who are particularly interested in additives may wish to refer to a previous issue of this publication for a more detailed discussion.[1]

Processing Research on Base Oils

Much has been made, and rightly so, of the importance of additives in formulating the oils required by the modern high power automotive engines. However, a well-balanced motor oil program should also provide for a continuing investigation of base oil manufacture. The reasons for this are twofold; not only must present processes be continually improved for economic reasons but also radically different manufacturing procedures must be considered, since therein may lie the key to some future need. For example, if solvent refining research had not provided a way to make available unlimited quantities of high quality motor oil base stocks, the development of improved automotive engines would have been seriously hindered.

Effective Liaison with Car Manufacturers

In addition to suitable research facilities and a capable staff, effective motor oil development requires close liaison with car manufacturers. This stems primarily from the point previously made — that one of the problems of motor oil research is to anticipate the needs of future engines. Regular contacts with the advanced engineering staffs of car manufacturers can be of invaluable help in this connection.

Since car manufacturers are the first to learn of any operational difficulties with their products, frequent meetings with their engineering and service personnel also serve to alert the oil manufacturer to new requirements that current oils are required to meet.

Finally, these contacts permit the standardization of testing procedures so that data on new oil developments will be of maximum significance to the car producer.

Cooperation of Sales and Technical Service Personnel

Motor oil research and development also relies heavily on information from the petroleum company's sales department personnel. This information can usually be relayed most effectively through technical service representatives. Through their more intimate contact with the consumer, the sales force can frequently anticipate areas where motor oil performance can be improved. Some complaints are inevitable with a product marketed over a large area. This is particularly true in the case of motor

[1]Lubrication, March, 1957

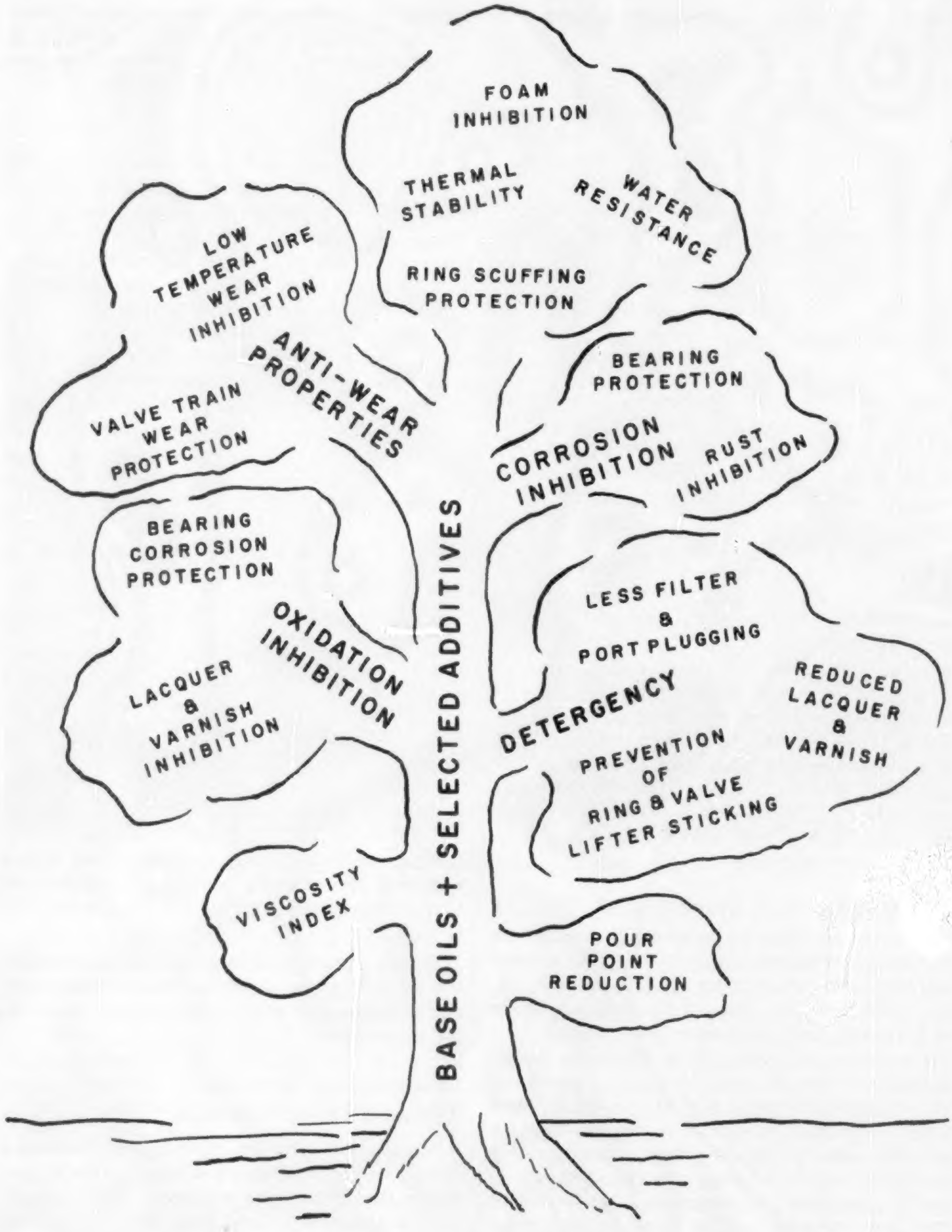


Figure 3 — Additive "Tree"

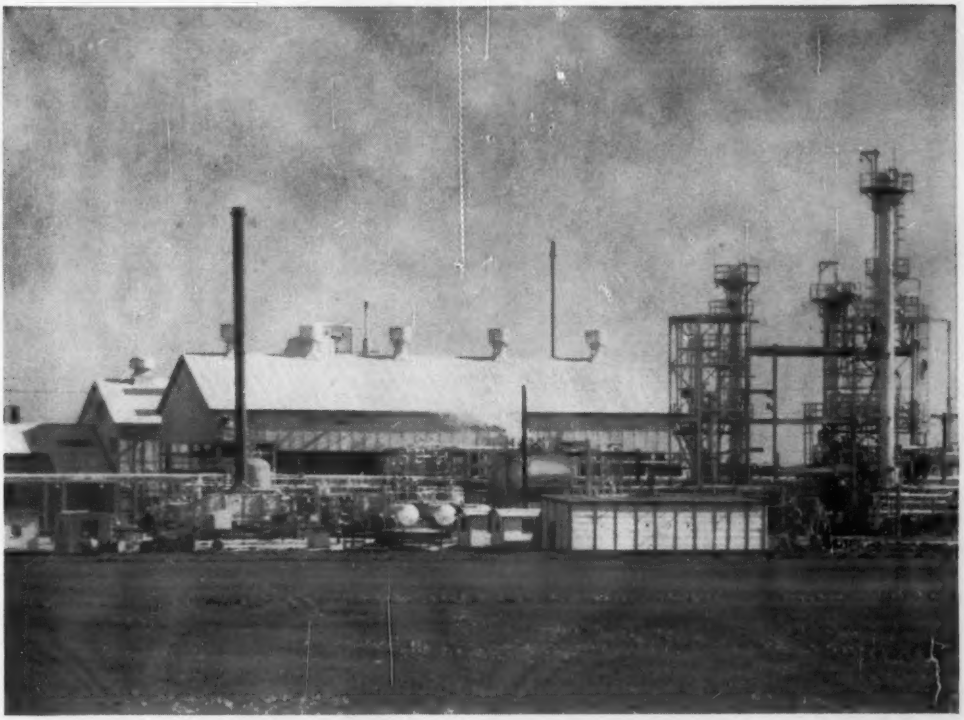


Figure 4 — Manufacturing facility for lubricating oil additives

oil where mechanical difficulties are often mistakenly attributed to the crankcase lubricant. However, an objective analysis of these complaints will usually reveal a small number relating to some characteristic of the oil which can be improved. This type of information is most helpful to the research staff. Sales personnel are also frequently the first to learn of improvements in competitive products which must be taken into account in charting current development work and future research.

HYPOTHETICAL CASE HISTORY

In the preceding discussions a *modus operandi* for effective motor oil research has been considered. A hypothetical case history will now be examined, as an illustration of the way in which the various facilities cooperate to handle a specific problem in motor oil development.

Let it be supposed that managerial analysis of information from the various sources previously mentioned indicates the desirability of placing a new motor oil on the market by a specified date. The characteristics desired in the new product have been outlined and the cost limitations have been set.

Plan of Action

If the research program and its supporting activities, including fundamental studies, test development, additive synthesis and base oil improvement, have been functioning properly, much of the groundwork will already have been laid.

However, in any case, some immediate and pressing decisions will usually have to be made. These may involve such questions as: *How can the desired improvement be made without sacrificing any previous advances?* Motor oil development involves certain compromises, particularly from the standpoint of additive balance. An additive which improves one characteristic may degrade another. *Which additives give the best combination of quality and economy?* Even though plant-scale additive manufacturing facilities, such as those shown in Figure 4, may be available, the decision regarding the proposed new oil may mean extensive additions or modifications thereto. *Will the new product require substantially different base stocks than those now in use?* If so, some assurance must be had that it will be available in sufficient quantity over a period of years. Also, any additions to existing refining equipment must be considered. Processing units such as the ones

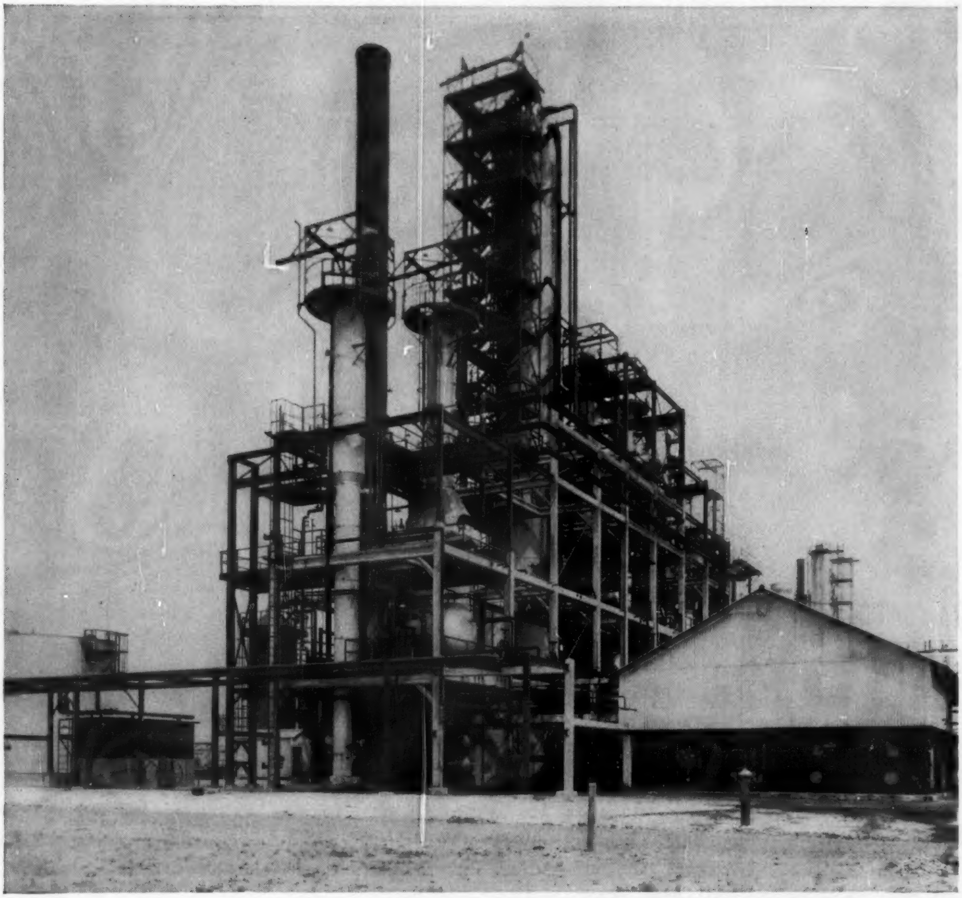


Figure 5 — Lubricating oil solvent refining unit

shown in Figures 5 and 6 are expensive, but their cost can be justified if they permit the manufacture of higher quality products at a reasonable cost.

With these decisions made, and the fruits of previous work to draw on, the task becomes one of obtaining as rapidly as possible a really formidable mass of data covering almost every conceivable aspect of motor oil performance. A framework of data will probably already be at hand. When all of the blank spaces are eventually filled in, the oil manufacturer will review the data with utmost care to be certain that no serious difficulty will arise when his new oil reaches the market.

Complete Bench Test and Laboratory Engine Evaluations

Some idea of the extent of this type of testing is revealed by turning again to Figure 3, the "Additive Tree". Among the properties evaluated are:

Wear

This includes the three best-recognized types of wear, namely, that due to corrosion, that due to scuffing, welding, and surface disintegration and that due to abrasion from extraneous contamination such as road dirt. Corrosive wear occurs for the most part under low temperature driving conditions, and can be very effectively controlled with additives. Wear due to scuffing, welding and surface disintegration is exemplified by the valve train wear which was encountered frequently several years ago. This problem has been alleviated by a combination of additive treatment and metallurgical changes, but it must still be taken into consideration in any new product.

Bearing Corrosion Protection

This refers primarily to protection of connecting rod and main bearings against possible corrosive effect of oil and fuel oxidation products. Many bearing materials, such as babbitt, silver, aluminum, bronze, and copper-lead, are in use and must be tested to assure satisfactory performance with the new product.

Rust Protection

Rusting of engine parts is particularly apt to occur during the winter months. During this time of year, particularly if one does much stop-and-go driving, water vapor may condense in the crankcase, and rusting may occur if the motor oil does not have adequate rust inhibiting properties.

Engine Cleanliness

This embraces not only low temperature and high temperature gasoline engine deposits but also automotive and industrial *diesel* engine cleanliness. The latter must be evaluated since many customers use one oil in both gasoline and diesel equipment. Engine deposits in this connection include such items as piston varnish and lacquer, oil ring sludge, ring groove carbon, filter deposits, oil pan sludge, and hydraulic valve lifter deposits.

Viscosity-Temperature Properties

Here one is concerned with low temperature viscosity in relation to ease of starting during the winter, high temperature viscosity in relation to adequate lubrication under sustained moderate to high speeds, and finally, viscosity stability. The latter refers to the ability of an oil to retain its viscosity after being subjected to extensive shearing stresses, such as occur for example when a shaft is turning at high speed in a heavily loaded bearing.

Thermal and Oxidation Stabilities

Thermal stability refers to the ability of the oil components, both base oil and additive to resist degradation or "cracking" due to the effects of heat alone. The products of thermal decomposition may be corrosive, or they may be carbonaceous and thereby promote wear, besides adding to engine deposits. *Oxidation stability* refers to the ability of the oil to resist degradation due to reaction with oxygen at elevated temperatures. The adverse effects of poor oxidation stability are similar to those already listed for poor thermal stability.

Effect on Fuel Combustion

It is known that improper formulation of crankcase oil can have an adverse effect on fuel combustion in a gasoline engine. This unfavorable effect consists of a build-up of combustion chamber deposits, which may give rise to engine knock and other uncontrolled combustion effects such as "preignition". In the latter events, a more expensive, higher octane number fuel may be required to give knock-free performance.

These effects can be minimized by the proper choice of base oil and can be further reduced by the use of certain motor oil additives.

Resistance to Foaming

The nature of the base oil, certain additives, and of course the application to which the oil is subjected all may contribute to foaming. Since excessive foaming could result in loss of oil from the crankcase and inadequate lubrication due to the diluting effect of entrained air, it is necessary to employ foam inhibitors in today's high quality motor oils. Effective inhibitors are available, but they must be selected and tested for each particular oil formulation to secure best results.

Effect on Seal Materials

By seal materials is meant the various natural and synthetic compounds used throughout the engine, transmission and hydraulic systems to prevent leakage of lubricant. The effect of a prospective new motor oil on representative seal materials must be thoroughly investigated.

Effect on Packaging Materials

Since the proposed new motor oil will be marketed in a number of different type containers or packages, the manufacturer must be sure that the oil will not have any adverse effect on the materials from which the packages are made. For example, although the cement used to seal the side seam of the familiar motor oil can was developed especially for this purpose, a new motor oil formulation might soften or otherwise degrade it. In addition, any dissolved sealing material would degrade the oil. In either event, it would of course be necessary to modify either the oil or the container. For a comprehensive discussion of packaging materials in the petroleum industry, the reader is referred to a previous issue of this publication.[1]

Compatibility

It is inevitable that any product as widely marketed as a motor oil will be used in combination with other oils in actual service. The products with which it may be mixed, intentionally or otherwise, will include not only competitive motor oils, but also other of the manufacturer's crankcase lubricants and even non-crankcase products such as turbine oils, for example. The testing program on a new oil should therefore include some evaluation of mixtures with

[1] Lubrication, December, 1957

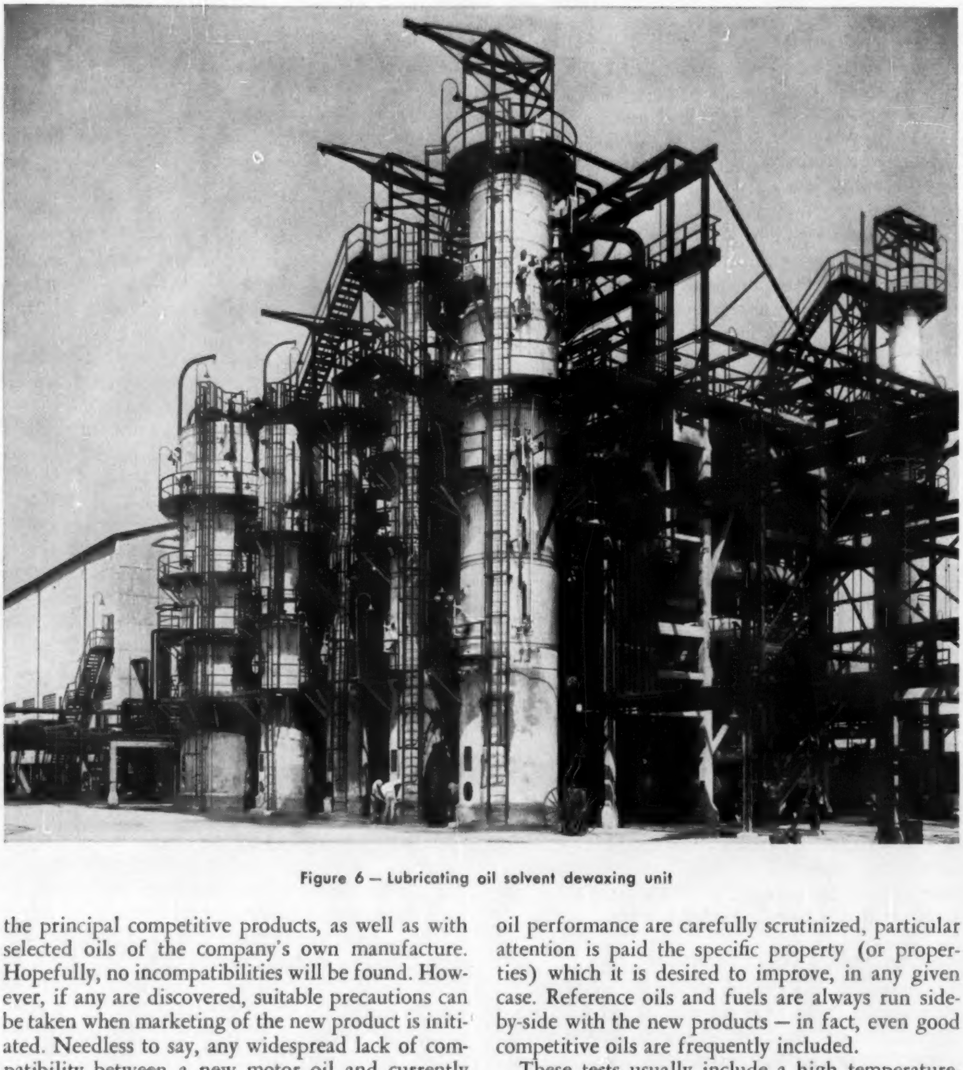


Figure 6 — Lubricating oil solvent dewaxing unit

the principal competitive products, as well as with selected oils of the company's own manufacture. Hopefully, no incompatibilities will be found. However, if any are discovered, suitable precautions can be taken when marketing of the new product is initiated. Needless to say, any widespread lack of compatibility between a new motor oil and currently available products would be a serious obstacle to successful marketing of the new oil.

Road Testing

Assuming that the new material has shown all of the desired characteristics in laboratory testing, it is now ready for an exacting and expensive series of road tests.

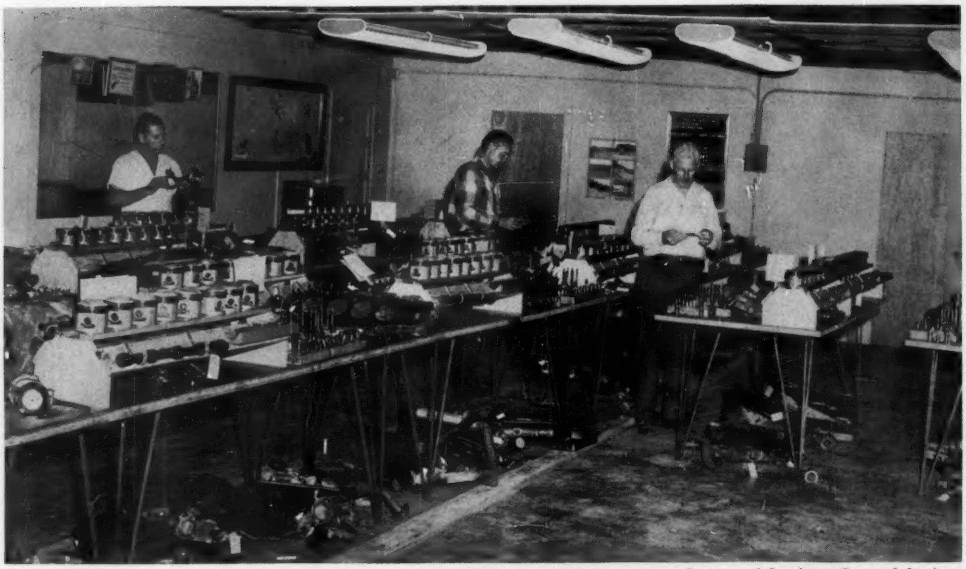
The purpose of road testing is, of course, to assure that performance achieved in the laboratory will actually be attained in the field, and that no problems unrecognized in the laboratory will be encountered in service. While all aspects of motor oil performance are carefully scrutinized, particular attention is paid the specific property (or properties) which it is desired to improve, in any given case. Reference oils and fuels are always run side-by-side with the new products — in fact, even good competitive oils are frequently included.

These tests usually include a high temperature-high speed test, a low temperature test, and some kind of commercial operation which involves considerable idling and stop-and-go driving. In any case, no dependence is placed on results with one or two cars — fleets of new cars are run for many thousands of miles to build up sufficient mileage to permit valid conclusions to be drawn.

High Temperature-High Speed Road Test

This is primarily an oil endurance test, run at speeds and crankcase temperatures which are considerably more severe than any that might normally be expected in actual service. In fact, the best

Figure 7 — Test fleet on the road



Courtesy of Southwest Research Institute

Figure 8 — Visual inspection of engine parts at conclusion of road test

motor oils are now so good that attempts to increase test severity through increasing speeds sometimes gives rise to mechanical failures which becloud the results. This test requires a suitable stretch of highway or turnpike such as that shown in Figure 7, where traffic conditions and terrain allow sustained high speeds to be maintained. A high speed test track is also suitable. Test cars must be very carefully prepared if the final results are to be significant. This requires complete disassembly of the engines in order to weigh bearings and piston rings, and to measure valve lifters, cylinder bores, camshaft lobes, rocker arm assemblies, valves and pistons. This not only permits the amount of wear and corrosion to be subsequently measured but also assures compliance with car manufacturers' recommendations and adjustments.

At the end of such a test the engines are disassembled and laid out on tables where each component can be carefully inspected visually, weighed or measured. Experienced observers, such as those shown in Figure 8, perform this final all-important task. If the hypothetical new oil is judged to have given satisfactory results, i.e., passed these extensive and rigorous tests, the refiner can feel confident that it will stand up under the most severe high speed treatment it is likely to meet in service.

Low Temperature Road Test

The high speed-high temperature road test cannot, by its nature, give any information on the important but opposite problem of low temperature performance. An entirely different test course and operating procedure are therefore used in low temperature road testing. The object is to simulate winter driving conditions, which promote low temperature deposits, low temperature wear and rust formation.

Instead of sustained high speeds as in the high temperature test, the low temperature procedure calls for cycling of both speed and crankcase temperature. It has been found desirable to employ a test course having a relatively high altitude (because of the lower ambient temperatures associated with high altitudes), and one which also varies considerably in elevation. The latter permits greater flexibility in attaining the desired cycling of crankcase temperatures.

A profile of a typical test course is shown in Figure 9. In a recent test using this course the cars started at Station 1 and proceeded to Station 2. After a cooling-down period, the cars were driven to Station 3 and again allowed to cool down. They then returned to Station 1 by the same route without stopping and after a cool-down period, repeated the cycle.

The same careful preparation of test cars and final disassembly of engines previously outlined must also be followed in the low temperature test. However, during inspection of each engine, emphasis is placed on those areas where low temperature operation is known to be critical.

Here, as in the high temperature test, satisfactory performance of an experimental motor oil assures the manufacturer that his product can handle the problems of winter driving with ease.

Fleet Tests

In order to gain as much information as possible on the performance of a new motor oil under stop and start city type operation, the high and low temperature road tests are frequently supplemented by tests in some kind of commercial car fleet. Taxicab fleets are attractive for this purpose since they build up mileage rapidly. Furthermore, considerable of the running time is spent in idling, and an evaluation of the effect of this very severe type of operation (from the standpoint of engine deposits) may be obtained.

Manufacturers' Approvals

Automobile manufacturers are understandably concerned that any widely marketed motor oil lubricate their engines satisfactorily. They also have the problem of selecting oils to be used by them as reference oils or standards for their own test programs. Therefore, as soon as road tests have been successfully completed, or possibly before, it is desirable to supply the principal car manufacturers with samples of the proposed new motor oil, along with the accumulated data. They may wish to satisfy themselves that the oil performs acceptably in their engines, and, if they find it of sufficiently high quality, they may want to adopt it as their standard crankcase lubricant.

Military Qualification

Approval of a new motor oil against military specification MIL-L-2104A is necessary if it is to be offered for sale to the government or to government contractors. This qualification also stamps the product in a way that is widely recognized in this country as suitable for heavy duty gasoline engine use. Many oil manufacturers, therefore, consider it essential to obtain this qualification on any new motor oil. In order to qualify, an oil must give satisfactory results in both the 36 hour Chevrolet L-4 gasoline engine test and the 480 hour Caterpillar L-1 Diesel engine test, in addition to meeting the viscosity and other physical test requirements of the specification. The fuel used in the Caterpillar L-1 diesel test for regular MIL-L-2104A qualification has a sulfur content of about 0.35 per cent. If an oil can pass this test using a special, more severe, fuel of approximately 1.0 per cent sulfur content, and can also meet the Chevrolet L-4 and physical test requirements it may be submitted for qualification as a "Supplement I" oil. The latter designation stamps the oil as being suitable for moderately severe *diesel* engine service, as well as for heavy duty gasoline operation. The actual qualification is obtained by submitting engine

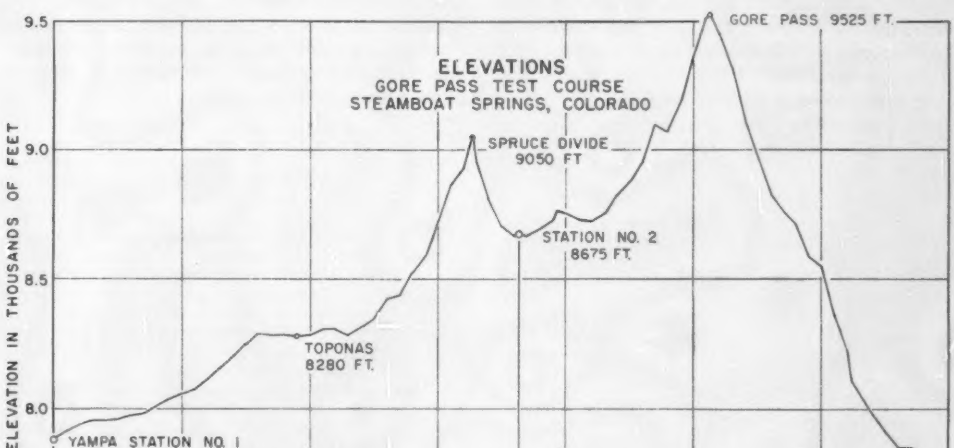


Figure 9 — Altitude profile of typical low-temperature road test course

tests results and other data to the Ordnance Review Board who place the oil on the qualified products list if they are satisfied that it meets the specification requirements.

Storage and Handling

At a fairly early point in the comprehensive test program which has already been outlined, an evaluation of storage stability under a variety of conditions will have been started. This information will be needed by the refiner's manufacturing division when actual production of the new product is begun. Satisfactory storage stability data will also insure that the oil will not deteriorate in the containers after it leaves the plant.

Sometimes a new formulation requires special handling during manufacture, and information on this point must also be developed.

Unusual Applications

Experience has shown that, primarily because of their wide availability, motor oils may be used on occasion for a variety of other applications. It is desirable to try to anticipate these unusual applications, not only to outline the areas where substitute or emergency use is permissible, but also to avoid usage which would be likely to give unsatisfactory performance. As an example of the latter situation, it is recommended that some motor oils not be used in light aircraft engines and air compressors. On the other hand, use of motor oils as hydraulic fluids would usually be quite satisfactory. A good rule for the consumer to follow is always to use petroleum products in accordance with the oil refiner or equipment manufacturer's recommendations.

The New Product is Launched

With all the preceding hurdles safely cleared, the way is now open for general marketing of the new motor oil. At this point, the manufacturing, distribution, advertising and sales organizations of the company will be ready to accelerate their activities. Each of these organizations will have already been alerted to the new development and will be prepared to expedite performance of its responsibilities in getting the new oil to consumers throughout the nation. Thus, the product which had its beginning perhaps years before in the laboratory now takes over the exacting job of lubrication for which it has proven itself so well fitted.

In the meantime, research leading to even better products goes on uninterruptedly. In the parlance of the sporting world, even though the new champion is securely enthroned, a worthy challenger is already in training.

SUMMARY

Successful development of motor oils to the point of marketing require the coordinated efforts of many individuals and groups within a petroleum company's research and technical organization. These range through basic research, lubricating oil processing research and development, additive research and development, bench testing, full-scale engine testing, and road testing. Particularly during the final stages of preparing a new motor oil for marketing it is important to maintain close liaison with car manufacturers. The petroleum refiner who wishes to be in a position to meet the ever more exacting requirements of his motor oil customers must plan on a concerted and continuing program of research and development.

INDEX OF MAGAZINE LUBRICATION

1949 THROUGH 1958

NOTICE: The following index of the last 120 issues is furnished only as a research convenience. As indicated below, extra copies may or may not be available. The full title and date of each issue is printed in heavy bold lettering: from two to twelve additional cross-indexed references are given in standard type. The ten annual issues of similar month are also grouped under the name of the month.

EXTRA COPIES: Extra copies are readily available during the month after issue, decreasingly so up to two years and only occasionally thereafter. Address requests to Mr. C. R. Frohlin, The Texas Company, 135 East 42nd Street, New York 17, New York.

A

B

C

D

E

F

M

N

O

P

Q

R

S

T

U

V

W

X

Printed in U. S. A. by
Salley & Collins, Inc.
305 East 45th Street
New York 17, N. Y.

New All-Temperature Havoline gives maximum protection against wear

HERE'S WHY:

1. You get maximum protection against cold-start wear! Unlike ordinary motor oil, all-temperature Havoline Special 10W-30 stays free-flowing even in dead of winter. Coats surfaces with a rust-proof, scuff-proof film the instant you flick the starter. You start faster. You get maximum protection against *hot-running wear!* Havoline's tough body resists extremes of engine heat and pressure.

2. You get greater gasoline mileage, pep and power. There's always a protective film between moving parts, such as all-important cams and valve lifters.

3. You get maximum protection against sludge and deposits. *This oil cleans as it lubricates!* Prevents sludge and deposits so engine runs smoother, quieter, more reliably. Change your oil every 1,000 miles and make sure it's all-temperature Havoline Special 10W-30 . . . *the best motor oil your money can buy!*

THE TEXAS COMPANY • • • DIVISION OFFICES

ATLANTA, GA......864 W. Peachtree St., N.W.
BOSTON 16, MASS........20 Providence Street
BUFFALO 5, N. Y................P.O. Box 368
BUTTE, MONT..........220 North Alaska Street
CHICAGO 4, ILL......332 So. Michigan Avenue
DALLAS 1, TEX.........1512 Commerce Street
DENVER 3, COLO...........1570 Grant Street
HOUSTON 2, TEX.......720 San Jacinto Street
INDIANAPOLIS 1, IND., 3521 E. Michigan Street
LOS ANGELES 5, CAL......3350 Wilshire Blvd.
MINNEAPOLIS 3, MINN......1730 Clifton Place
NEW ORLEANS 16, LA.......1501 Canal Street
NEW YORK 17, N. Y......205 East 42nd Street
NORFOLK 2, VA......3300 E. Princess Anne Rd.
SEATTLE 1, WASH..........1511 Third Avenue

Texaco Petroleum Products are manufactured and distributed in Canada by McColl-Frontenac Oil Company Limited.